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FOODS OF THE RED PORGY, *PAGRUS PAGRUS* LINNAEUS (PISCES: SPARIDAE), FROM NORTH CAROLINA AND SOUTH CAROLINA

Charles S. Manooch III

ABSTRACT

Digestive tracts of 779 red porgy, *Pagrus pagrus*, 46 to 625 mm total length, collected by hook and line and trawl off North Carolina and South Carolina from May 1972 through April 1974 were examined. Ninety-seven percent of the specimens contained food representing 69 taxa of organisms. Seventy-four percent of the foods (and 60% of the volume) of adult *Pagrus* was composed of obligate benthic animals and approximately 90% of the diet was of organisms which live near the bottom. Invertebrates represented primarily by crustaceans, mollusks, and echinoderms, occurred in 89% of the adult fish. Crabs, mainly majids, portunids, and calappids were the predominant food by both frequency of occurrence and volume. Fish representing 14 families occurred in 24% of the stomachs and comprised 15% of the food volume of adult red porgy. While larger juveniles, 130 to 162 mm total length, ingested similar foods as adults, small juveniles, 46–64 mm, fed on amphipods, copepods, stomatopods, and annelids. Slight differences in frequency occurrence of organisms in the diet were noted between geographical areas, depths, and seasons. Size of red porgy produced a more pronounced effect on the diet.

In January 1972, the National Marine Fisheries Service Center at Beaufort, North Carolina initiated an acquisition program for catch statistics and biological data for demersal fishes which live on the outer Continental Shelf of North Carolina and South Carolina. Warm Gulf Stream water and irregular bottom topography create a suitable habitat for eurythermic temperate species and for tropical and subtropical fish commonly associated with Caribbean and Bahamian reefs and banks (Huntsman and Manooch, 1974). These populations support a thriving sport fishery in North Carolina and South Carolina (Sekavec and Huntsman, 1972; Huntsman, 1976).

Included in the studies undertaken by the bottom fisheries task was an investigation of the food habits of fishes inhabiting inshore reefs and the outer Continental Shelf. Emphasis was placed on species which contribute to the Carolina headboat[1] fishery. The red porgy, *Pagrus pagrus*, is the most frequently caught species; 49% by number and 42% by weight of all fish caught (Huntsman, 1976). From 1972 through 1974, 750,072 individuals weighing 1.8 million pounds were taken by sport fishermen fishing aboard North Carolina and South Carolina headboats (Huntsman, 1976). Although the red porgy is a vital member of the offshore demersal fish community and supports an extensive fishery, only recently has extensive research been conducted on the species in the western Atlantic (Ciechomski and Weiss, 1973; Manooch, 1975; Manooch et al., 1976; Manooch, 1976; Manooch and Huntsman, 1977; Cotrina and Cousseau, unpub. ms.[2]). Several authors briefly mention red porgy feeding (Bearden and McKenzie, 1969; Cotrina and Cousseau, unpubl. ms.[2]; Austin, unpubl. ms.[3]) without presenting quantitative data.

Specific objectives of this study were to: (1) describe the general food habits of red

[1] A boat for hire which charges by the individual fisherman.

[2] Carmen P. Cotrina and M. B. Cousseau Informe sobre el muerto bioestadístico desembarque de pescado en el Puerto de Mar del Plata, Argentina. Periodo Enero de 1972–Diciembre de 1974. Instituto de Biología Marina, Mar del Plata, Argentina.

[3] Herbert M. Austin. Dept. of Oceanogr., Florida State Univ., Tallahassee, Florida 32306.

porgy collected from North Carolina and South Carolina, (2) compare the effects of season, area of collection (geographic area and depth), and size of fish on types of foods eaten, and (3) describe feeding in relation to proximity with the bottom.

Materials and Methods

From May 1972 to April 1974, 779 red porgy ranging between 46 and 625 mm total length (TL) were collected from North Carolina and South Carolina waters. A majority (524) of the fish were > 200 mm total length and were obtained from the recreational fishery. Red porgy in the size category 202 to 625 mm TL will be referred to as adult or "adult form" in this paper although smaller individuals in this size range have not reached sexual maturity (Manooch, 1976). Additional adults were provided by experimental hook and line fishing aboard the 48-foot Onslow Bay, an Atlantic Estuarine Fisheries Center research vessel. Hook sizes used by the fishery selectively exclude fish < 200 mm TL but 78 juveniles, or young-of-year (Manooch and Huntsman, 1977) were collected by trawling off South Carolina.

Although samples were collected from several hundred individual sites off the Carolinas, three major geographic areas are referred to in this study (Fig. 1). Area 1, Cape Lookout, includes Raleigh and Onslow Bays vicinity; Area 2, Cape Fear, lower Onslow Bay to the South Carolina border; and Area 3, Cape Romain, from the South Carolina border to Charleston. Fish were not only stratified by area of collection but also by depth within each area. Collections made in depths greater than 50 m (usually 70 to 120 m) are referred to as "offshore" and those from less than 50 m (usually 23 to 43 m) are referred to as "inshore" (Fig. 1). To facilitate analysis and presentation of data, monthly samples were grouped into the following seasons: spring (March to May), summer (June to August), fall (September to November), and winter (December to February).

The stomachs and intestines were removed and preserved in 10% Formalin[4]; other methods of preservation have proven ineffective (Manooch, 1973). In the laboratory, digestive tract contents were removed. Food organisms were then separated taxonomically, and measured volumetrically by water displacement. Numbers of each taxon could not be determined since foods were partially digested and usually crushed by the molariform teeth. Frequency of occurrence of food types was obtained by counting every fish that contained the specific item. Relative frequency of occurrence (%) was obtained by dividing the number of fish that contained a specific item by the total number of red porgy that contained food. To determine the red porgy feeding position in the water column, foods were grouped into three categories: benthic, semibenthic, and nektonic. These data were presented by frequency of occurrence and volume.

Results

Synopsis of Various Food Types

Invertebrates.—Invertebrates were the principal foods of the red porgy and occurred in 89% of the 679 adult fish containing food, and were 72% of the volume (Table 1, Fig. 2). Seven families of crabs, represented by 22 species, were identified (Table 2). Majids, portunids, and calappids occurred most frequently. All other crustaceans occurred in less than 10% of the fish. Shrimp were divided into two size categories "large" (> 50 mm) and "small" (< 10 mm). Usually a stomach contained either one or two large shrimp, *Hymenopenaeus* and *Sicyonia*, or many small, *Leptochela* individuals. Juvenile (46 to 64 mm) red porgy fed on a variety of small crustaceans including copepods, amphipods and isopods which were absent in all fish larger than 64 mm TL (Table 3).

Mollusks, including cephalopods (squid, octopus), bivalves and gastropods were

[4] The mention of trade names does not imply endorsement by National Marine Fisheries Service, NOAA.

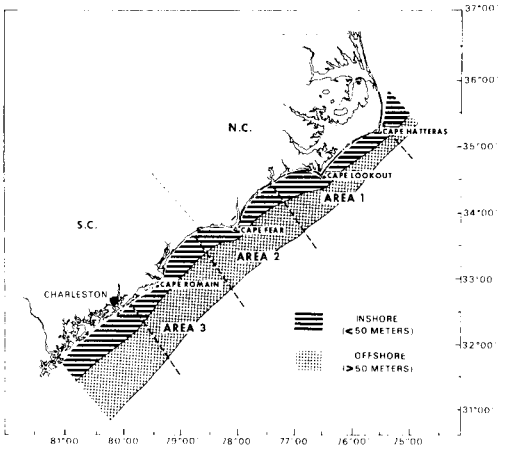

Figure 1. Coastal map of North and South Carolina indicates inshore and offshore locations within each geographic area, from which *Pagrus pagrus* were collected.

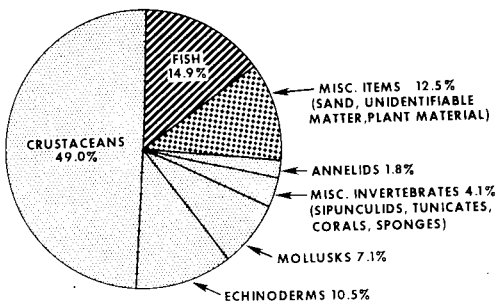

Figure 2. Stomach contents of 679 adult *Pagrus pagrus* (202–625 mm TL) captured off North and South Carolina, May 1972 to April 1974 expressed as percent volume.

found in approximately 28% of the larger (202–625 mm TL) fish stomachs but composed only 7% of the volume (Table 1). Large numbers of crushed bivalves often occurred in a single fish.

Echinoderms equaled mollusks in importance, occurring in 26% of the adult fish stomachs and representing 10% by volume (Table 1, Fig. 2). Brittle stars, starfish, sea urchins, sea cucumbers, sand dollars, and crinoids were found (Table 2). Sea urchins occurred most often (12%), and had the largest percentage of the echinoderm volume (4%).

Recent investigations by biologists examining foods of red porgy and other sparids reveal similarities in the diet with respect to invertebrate foods. Bearden and McKenzie (1969) found *Pagrus* collected off South Carolina contained a variety of crabs (majids, xanthids, and portunids), polychaetes, and mollusks. Austin (unpubl. ms.[3]) identified crabs and echinoderms in the stomachs of red porgy from the Gulf of Mexico. Cotrina and Cousseau (unpubl. ms.[2]) found red porgy from Argentine waters contained fishes, mollusks, crabs, sessile coelenterates, polychaetes, amphipods, and echinoderms. Hobson (1974), found that *Monotaxis grandoculis* feeds primarily on gastropods, echinoderms, and crabs on coral reefs in the Pacific. Godfriaux (1973) determined that *Chrysophrys auratus* fed on crustaceans, polychaetes, mollusks, and echinoderms in New Zealand waters. Randall (1967, 1968) found *Calamus*, a closely related American genus, to be carnivorous feeding on a variety of mollusks, crustaceans and echinoderms.

Fish.—Fish were not as important as invertebrates in the diet of adult red porgy occurring in 24% of the specimens containing food, and composing 15% of the total food volume (Table 1, Fig. 2). Despite the fact that fish were usually digested beyond recognition, 16 species representing 14 families were identified (Table 4). It should be noted that, with a few exceptions, the species observed are usually closely associated with the bottom and exhibit solitary, nonschooling behavior. Lined seahorse, *Hippocampus erectus*, and pipefish, *Syngnathus* sp., were fed upon most frequently.

Miscellaneous.—Some of the materials found in digestive tracts were not considered food and were probably ingested incidental to normal feeding. Examples were sand, plant matter, and a sting ray egg case (Table 1). The sand may have come from the alimen-

Table 1. Digestive tract contents of 679 adult red porgy, *Pagrus pagrus* (202–625 mm TL) collected off North and South Carolina, May 1972–April 1974 (Selected food items are classified as benthic, B; semibenthic, S; and nektonic, N)

Food Item	Frequency of Occurrence	Relative Frequency of Occurrence (%)	Volume (ml)	Relative Volume (%)
Fish—S	164	24.2	798.7	14.9
Invertebrates	606	89.3	3,881.8	72.6
Crustaceans	517	76.1	2,622.6	49.0
Crabs	402	59.2	1,846.5	34.5
Paguridae—B	41	6.0	56.0	1.1
Parthenopidae—B	41	6.0	84.0	1.6
Majidae—B	96	14.1	332.3	6.2
Albuneidae—B	45	6.6	214.5	4.0
Xanthidae—B	32	4.7	99.1	1.9
Calappidae—B	77	11.3	325.6	6.1
Portunidae—S	93	13.7	449.8	8.4
Unid. crab	110	16.2	285.2	5.3
Barnacles—B	13	1.9	51.3	1.0
Scyllaridae—B	40	4.6	89.2	1.7
Stomatopods—S	40	5.9	89.0	1.7
Galatheidae—S	1	0.2	3.5	0.1
Small shrimp—N	34	5.0	265.7	5.0
Large shrimp—N	25	3.7	75.0	1.4
Unid. crustaceans	72	10.6	202.4	3.8
Echinoderms	175	25.8	560.8	10.5
Brittle stars—B	38	5.6	105.6	2.0
Starfish—B	2	0.3	9.0	0.2
Sea urchins—B	81	11.9	215.1	4.0
Sea cucumbers—B	29	4.3	91.9	1.7
Sand dollars—B	9	1.3	73.0	1.4
Crinoids—B	11	1.6	20.8	0.4
Unid. echinoderms—B	24	3.5	45.4	0.9
Mollusks	194	28.6	381.3	7.1
Squid—N	17	2.5	59.1	1.1
Octopus—S	3	0.4	34.0	0.6
Pelecypods—B	120	17.7	210.8	3.9
Gastropods—B	84	12.4	77.4	1.5
Annelids	50	7.4	98.3	1.8
Polychaetes—B	50	7.4	98.3	1.8
Misc. Invertebrates	46	6.8	218.8	4.1
Sipunculids—B	8	1.2	48.5	0.9
Soft corals—B	3	0.4	0.3	–
Corals—B	14	2.1	3.0	0.1
Tunicates—B	18	2.7	160.5	3.0
Sponge—B	3	0.4	6.5	0.1
Misc. Foods	231	34.0	667.5	12.5
Sand	39	5.7	82.0	1.5
Plant material	15	2.2	8.3	0.2
Unid. matter	185	27.8	576.0	10.8
Sting ray egg case	1	0.2	1.2	–
Empty—22	679	3.1		
Total—701			5,348.0	

Total classified food categories: 31. Percentage of food categories (31) by classification: B, 74.2%, S, 16.1%, and N, 9.7%. Total classified food volume: 4,192.9 ml. Percentage of volume by classification: B, 59.8%, S, 32.4%, and N, 7.7%.

Table 2. List of invertebrates identified in digestive tracts of 679 adult *P. pagrus* (202–625 mm TL)

- Crustaceans
  - Paguridae
    - *Dardanus insignis*
    - *Pagurus* sp.
  - Parthenopidae
    - *Parthenope agona*
    - *Parthenope serrata*
    - *Parthenope pourtalesii*
    - *Parthenope fraterculus*
  - Majidae
    - *Anasimus latus*
    - *Stenorynchus seticornis*
    - *Mithrax pleuracanthus*
    - *Mithrax forceps*
    - *Stenocionops furcata coelata*
  - Albuneidiae
    - *Albunea gibbesii*
    - *Albunea* sp.
  - Xanthidae
    - *Pilumnus dasypodus*
    - *Pilumnus* sp.
    - Undescribed xanthid
  - Calappidae
    - *Calappa angusta*
    - *Hepatus epheliticus*
  - Portunidae
    - *Ovalipes ocellatus*
    - *Portunus sayi*
    - *Portunus ordwayi*
    - *Portunus spinicarpus*
  - Scyllaridae
    - *Scyllarus depressus*
  - Stomatopods
    - *Squilla deceptrix*
  - Galatheidae
    - *Munida irrasa*
  - Small shrimp
    - *Leptochela serratorbita*
  - Large shrimp
    - *Hymenopenaeus tropicalis*
    - *Sicyonia brevirostris*
    - Unidentified shrimp
- Echinoderms
  - Brittle stars
    - *Astroporpa annulata*
  - Starfish
    - Goniasteridae
  - Sea urchins
    - *Cidaris rugora*
  - Sea cucumbers (unidentified)
  - Sand dollars
    - *Mellita quinguiesperforata*
- Mollusks
  - Squid (unidentified)
  - Octopus
    - *Octopus vulgaris*
  - Pelecypods
    - *Laevicardium pictum*
  - Gastropods
    - *Vermicularia knorrii*
    - *Polinices uberinus*
    - *Marginella* cf. *M. apicina*
    - *Marginella* cf. *M. roscida*
    - *Nassarius albus*
    - *Anachis translirata*
    - *Erata maugeriae*
    - *Arene bairdii*
    - *Murex florifer dilectus*
    - *Senium maculatum*
  - Annelids (unidentified)
  - Miscellaneous invertebrates
    - Sipunculids (unidentified)
    - Soft corals
      - *Titanidium frauenfeldis* sp.
    - Coral
      - *Telesto fauticulosa*
    - Tunicates (unidentified)
    - Sponge (unidentified)

tary canals of annelids and sipunculids which had been digested by the red porgy.

Variation in Food Habits

Seasonal Variation in Food Habits.—Although the red porgy is an eurythermic, temperate species, noting its western Atlantic distribution (Randall, 1968), most of the specimens were collected offshore in a warm (16°–20°C) temperature stable environment. Even though seasonal variations in species composition of forage organisms would not be great in such an area, slight variation might be expected from local fluctuation in abundance.

Table 3. Digestive tract contents of 78 juvenile *Pagrus pagrus* divided into two size categories: 46–64 mm total length, and 130–162 mm total length collected by trawl off South Carolina, 1974

Food Item	46–64 mm (N = 28) Relative Frequency of Occurrence (%)	130–162 mm (N = 50) Relative Frequency of Occurrence (%)	130–162 mm (N = 50) Relative Volume (%)
Fish	0.0	9.1	0.0
Invertebrates	85.7	90.9	78.3
Crustaceans	85.7	63.6	27.6
Copepods	21.4	0.0	0.0
Amphipods	75.0	0.0	0.0
Isopods	3.6	0.0	0.0
Stomatopods	10.7	9.9	13.2
Crabs	0.0	9.1	4.6
Small shrimp	0.0	9.1	0.0
Unid. crustaceans	10.7	36.4	9.9
Echinoderms	0.0	63.6	36.8
Brittle stars	0.0	54.5	35.5
Sand dollars	0.0	9.1	2.0
Sea cucumbers	0.0	9.1	1.3
Unid. echinoderms	0.0	9.1	0.0
Mollusks	3.6	18.2	0.7
Pelecypods	0.0	9.1	0.0
Gastropods	3.6	9.1	0.7
Annelids	14.3	9.1	13.2
Polychaetes	14.3	9.1	13.2
Miscellaneous food items	100.0	27.3	21.7
Unid. digested matter	100.0	27.3	21.7

Table 4. List of fishes identified in digestive tracts of 679 adult *Pagrus pagrus* (202–625 mm TL)

Congridae
Conger oceanicus, conger eel
Ophichthidae
Ophichthus ocellatus, palespotted eel
Engraulidae
Anchoa sp., anchovy
Ogcocephalidae
Ogcocephalus parvus, roughback batfish
Ophidiidae
Rissola marginata, striped cusk-eel
Syngnathidae
Hippocampus erectus, lined seahorse
Syngnathus sp., pipefish
Serranidae
Centropristis striata, black sea bass
Diplectrum formosum, sand perch
Carangidae
Decapterus punctatus, round scad
Pomadasyidae
Haemulon aurolineatum, tomtate
Pomacentridae
Pomacentrus fascus, dusky damselfish
Labridae
Halichoeres garnoti, yellowhead wrasse
Scorpaenidae
Pontinus nematophthalmus, spiny throat scorpionfish
Triglidae
Prionotus sp., searobin
Balistidae
Aluterus schoepfi, orange filefish

Food habits of adults exhibited only slight seasonal variation (Table 5). Invertebrates were dominant food during all seasons, always occurring in more than 80% of the fish containing food and composed more than 50% of the volume. Frequency of fish in the diet ranged from 18% in summer to 33% in winter. The largest percentage of the total volume of fish (24%) also occurred during winter.

Several groups of invertebrates varied seasonally by volume and frequency of occurrence. Majid crabs were found in 30% of the stomachs in spring, three times more abundant than in summer and fall (Table 5). Shrimp, both large and small, occurred more frequently in summer. The volume for small shrimp was approximately 9% of the total food volume during summer, but was less than 1% in fall and winter, and only 3% in spring (Table 5). Pelecypods also reached a seasonal high in summer. Sipunculid worms and colonial tunicates also were seasonal in occurrence. Sipunculids were found only during winter and tunicates occurred in the diet only in spring and summer (Table 5).

Depth Related Variations in Food Habits

Foods found in the digestive tracts of 701 adult *Pagrus pagrus* stratified by inshore and offshore collection sites are listed in Table 6. Fish sampled from depths less than 50 m

Table 5. Digestive tract contents of 679 adult *Pagrus pagrus* (202–625 mm TL) collected off North and South Carolina from May 1972–April 1974, expressed as relative percent frequency of occurrence by season

Food Item	Relative Frequency of Occurrence (%)			
	Spring	Summer	Fall	Winter
Fish	29.2	18.3	22.4	32.8
Invertebrates	94.1	89.7	83.5	85.6
Crustaceans	89.3	72.1	77.7	67.2
Crabs	78.0	50.2	64.7	52.0
Paguridae	8.3	5.7	4.7	4.8
Parthenopidae	7.1	7.3	7.1	0.8
Majidae	29.8	10.0	10.6	5.6
Albuneidae	8.9	4.3	7.1	8.8
Xanthidae	8.9	4.0	2.4	2.4
Calappidae	16.1	11.6	11.8	4.0
Portunidae	22.6	7.6	14.1	16.0
Unid. crab	16.7	16.0	17.7	15.2
Barnacles	4.8	1.3	–	0.8
Scyllaridae	8.9	4.0	–	3.2
Stomatopods	11.3	4.0	3.5	4.8
Small shrimp	3.0	9.3	–	0.8
Large shrimp	1.2	7.0	1.2	0.8
Unid. crustaceans	5.4	13.3	14.1	8.8
Echinoderms	28.0	24.9	23.5	26.4
Brittle stars	6.6	4.3	8.2	5.6
Sea urchins	13.7	11.0	14.1	10.4
Sea cucumbers	3.6	4.7	1.2	6.4
Crinoids	2.4	0.7	2.4	2.4
Unid. echinoderms	5.3	3.0	2.4	3.2
Mollusks	29.8	30.9	24.7	24.0
Squid	1.8	3.3	–	0.4
Octopus	0.6	0.3	–	0.8
Pelecypods	13.1	22.9	10.6	16.0
Gastropods	19.6	9.0	15.3	8.8
Annelids	10.1	8.0	3.5	4.8
Polychaetes	10.1	8.0	3.5	4.8
Miscellaneous invertebrates	7.7	6.6	3.5	24.0
Sipunculids	–	–	–	6.4
Corals	4.2	1.7	1.2	0.8
Tunicates	1.8	5.0	–	–
Sponge	0.6	–	2.4	–

(inshore) were generally associated with rock outcroppings, coral heads, and shipwrecks or more specifically, "live-bottom" areas (Struhsaker, 1969). Red porgy collected in deeper water (> 50 m) were generally found at the break of the Continental Shelf. The bottom in this area is very irregular, particularly in the Raleigh Bay and upper Onslow Bay sections, and is composed of sandstone, limestone, and shell hash (MacIntyre and Milliman, 1970).

It is unlikely that species composition and relative abundance of various food organisms would be the same inshore compared with offshore. For example, the probability of a red porgy finding a parthenopid crab, a majid crab, or brittle star would be much greater in deeper water (personal observation). Although invertebrate distributions are not the same inshore and offshore, and depth related discrepancies in the diet were greatest of those observed, effect of depth

Table 6. Digestive tract contents of 159 adult *Pagrus pagrus* (202–625 mm TL) collected inshore (< 50 m) and 520 specimens captured offshore (> 50 m), from May 1972–April 1974, expressed as percent frequency of occurrence

Food Item	Relative Frequency of Occurrence (%)	
	Inshore	Offshore
Fish	31.9	21.7
Invertebrates	84.7	90.7
Crustaceans	65.0	79.7
Crabs	46.0	63.4
Paguridae	0.6	7.8
Parthenopidae	0.6	7.8
Majidae	8.0	16.1
Albuneidae	11.0	5.2
Xanthidae	1.2	5.8
Calappidae	4.9	13.4
Portunidae	10.4	14.7
Unid. crab	12.9	17.3
Barnacles	4.9	1.0
Scyllaridae	0.6	5.8
Stomatopods	8.6	5.0
Small shrimp	2.5	5.8
Large shrimp	3.1	3.9
Unid. crustaceans	6.8	11.8
Echinoderms	24.5	26.2
Brittle stars	0.6	7.2
Star fish	0.6	0.2
Sea urchins	9.2	12.8
Sea cucumbers	6.1	3.7
Sand dollars	4.9	0.2
Unid. echinoderms	5.5	2.9
Mollusks	26.4	29.3
Squid	1.2	2.9
Octopus	0.6	0.4
Pelecypods	22.1	16.3
Gastropods	6.1	14.3
Annelids	3.1	8.7
Polychaetes	3.1	8.7
Miscellaneous invertebrates	4.9	7.4
Sipunculids	4.3	0.2
Tunicates	–	3.5

was not believed significant (Manooch, 1975). Therefore, I did not stratify area or season by inshore and offshore fishing grounds.

Invertebrates occurred in approximately 91% of the fish collected offshore. Crustaceans were the main food items, 80%. Crabs which occurred more frequently in offshore collected specimens were: pagurids, parthenopids, majids, and calappids. Brittle stars and gastropods also were recovered more frequently from fish collected in deep water (Table 6). Colonial tunicates were identified only in offshore collected specimens. Fish collected offshore were somewhat less piscivorous than those collected from shallower water. Fish occurred in 22% of the offshore stomachs, but composed only 13% of the food volume.

Inshore, invertebrates were again the main foods eaten, 85%. Crustaceans, mainly crabs, occurred in 65% of the stomachs. Albuneid crabs and barnacles were noticeably more important in the diet inshore compared with offshore collected fish (Table 6). Echinoderms were found in 25% of the specimens. This value is close to that obtained from fish collected in deeper water (26%) although a couple of subgroup differences are revealed. Sand dollars, in particular, occurred more commonly inshore. Another difference in invertebrate foods was the higher frequency of sipunculid worms in digestive tracts of fish collected in shallow water. Fish occurred in 32% of the stomachs containing food and composed 23% of the food volume.

Variation in Diet Correlated to Area of Collection

Geographic location (Fig. 1) would not be expected to drastically effect the diet in this study since the habitats, whether inshore or offshore, are very similar for all three areas and there is a maximum latitudinal distance of only 50 mi. Foods identified in digestive tracts of red porgy, stratified by geographic area, are found in Table 7. Each of the geographical comparisons is discussed briefly under the separate headings which follow.

Cape Lookout.—Invertebrates were found in 90% of the specimens and contributed 73% of the total volume (Table 7). Majid crabs, portunid crabs, and brittle stars occurred more frequently than for the other two areas. Sipunculid worms and corals were found only in the Cape Lookout vicin-

Table 7. Digestive tract contents of 679 *Pagrus pagrus* (202–625 mm TL) expressed as relative frequency of occurrence (%) by geographic area from May 1972–April 1974

Food Item	Relative Frequency of Occurrence (%)		
	Cape Lookout	Cape Fear	Cape Romain
Fish	25.1	31.7	8.9
Invertebrates	89.6	89.1	87.3
Crustaceans	80.2	62.4	68.4
Crabs	65.9	43.6	36.7
Paguridae	7.0	1.0	6.3
Parthenopidae	6.8	1.0	7.6
Majidae	17.2	5.9	5.1
Albunediae	6.8	8.9	2.5
Xanthidae	5.4	2.0	3.8
Calappidae	12.6	8.9	6.3
Portunidae	16.4	5.9	6.3
Unid. crab	17.0	15.8	11.4
Barnacles	2.6	–	–
Scyllaridae	6.0	–	1.3
Stomatopods	5.8	7.9	3.8
Small shrimp	1.6	10.9	19.0
Large shrimp	3.0	5.0	6.3
Unid. crustaceans	12.1	5.0	6.3
Echinoderms	26.3	30.7	15.5
Brittle stars	7.6	–	–
Star fish	–	1.0	1.3
Sea urchins	12.8	8.9	10.1
Sea cucumbers	3.0	10.9	3.8
Sand dollars	0.1	5.0	1.3
Crinoids	1.8	2.0	–
Unid. echinoderms	4.0	3.0	1.3
Mollusks	26.1	28.7	44.3
Squid	2.2	2.0	5.1
Octopus	0.2	2.0	–
Pelecypods	14.0	21.8	35.4
Gastropods	13.8	7.9	8.9
Annelids	8.0	2.0	10.1
Polychaetes	8.0	2.0	10.1
Miscellaneous invertebrates	7.8	1.0	7.6
Sipunculids	1.6	–	–
Soft corals	0.6	–	–
Corals	2.8	–	–
Tunicates	2.2	1.0	7.6
Sponge	0.6	–	–

ity. Fish occurred in 25% of the stomachs and represented 16% of the volume.

Cape Fear.—As always invertebrates were the dominant foods (89%) but crustaceans were less important than the other areas and echinoderms occurred more frequently (Table 7). Fish collected in the Cape Fear area were more piscivorous than in the other two areas.

Cape Romain.—Food habits were very similar to the other two areas, invertebrates occurred in 97% of the digestive tracts, except there were fewer fish in the diet (9% compared with 25% for Cape Lookout and 32% for Cape Romain) and colonial tunicates were more abundant in the diet (Table 7). Also there appeared to be two trends in feeding related to decrease in latitude. Shrimps and pelecypods increased in frequency of occurrences from north to south.

Trends in relative frequency of occurrence for various food categories, especially majid, portunid and calappid crabs, brittle stars, pelecypods and gastropods between Cape Lookout and the other two areas are similar to those described under "variation in diet with depth." Most of the specimens from Cape Fear and Cape Romain were captured inshore, but the majority of the Cape Lookout specimens were caught offshore. Therefore, it is likely that geographic area (latitude) merely reflects differences in feeding attributable to depth of capture. Food studies of the vermilion snapper, *Rhomboplites aurorubens*, revealed no significant differences in the diet between the same geographic areas (Grimes, 1976).

Variation in Diet Correlated to Size of Red Porgy

Seventy-eight juvenile (46 to 162 mm TL) red porgy collected by trawl were analyzed for stomach contents (Table 3). To facilitate a comparison of the diet of juveniles and adults, I categorized the juveniles into two size classes: small (46 to 64 mm) and large (130 to 162 mm). These two size classes of young-of-year were established by the interval between trawling, April and then in November. The larger juveniles contained foods very similar to adult *Pagrus* although each taxon was generally much smaller in size. Invertebrates, mainly crustaceans, echinoderms and mol-

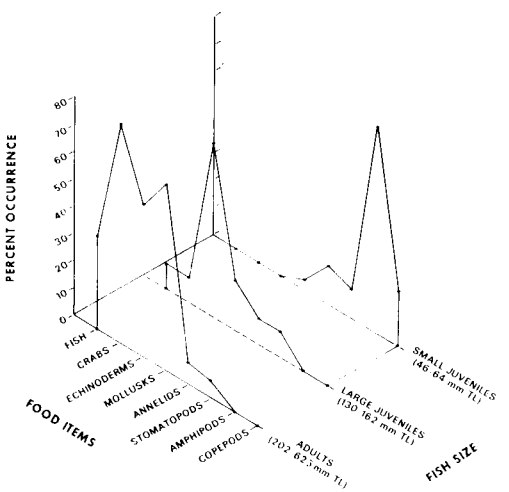

Figure 3. Selected foods of three size classes of red porgy: 202 to 625 mm TL, 130 to 162 mm TL, and 46 to 64 mm TL, expressed as percent frequency of occurrence.

lusks were the predominant food. As expected juveniles were less piscivorous than fish 202 to 625 mm TL; fish were identified in only 9% (Table 3) of the larger juveniles compared with 25% of the adults (Table 1).

The red porgy diet revealed the greatest change between small and large juveniles (Table 3, Fig. 3). The smaller juveniles (42–64 mm) fed primarily on crustaceans (86% by frequency). These crustaceans, however, were primarily amphipods and copepods; two groups not identified in either the large juveniles or adults.

Feeding Proximity to the Bottom

A primary objective of the study was to determine whether or not the red porgy feeds on bottom dwelling organisms or animals which may be consumed while up in the water column. Table 1 presents various foods divided into three categories: benthic, semibenthic, and nektonic expressed by volume and frequency of occurrence. The semibenthic category contains food organisms which may be nektonic but are associated with the substrate. A majority of the fishes identified fall under this classification (Table 4). Nektonic refers to those organisms which are free swimming and are found primarily up in the water column and benthic are those organisms which are closely associated with the substrate.

Seventy-four percent of the foods were classified as obligate benthic organisms; 60% by volume (Table 1). If semibenthic organisms are included, the percentages are increased to 90 and 92, respectively. Only 10% of the foods could be classified as nektonic, indicating that the *P. pagrus* diet is mainly contingent upon bottom dwelling organisms.

Discussion

My data suggest that the red porgy has a tremendously diverse diet and that contents probably reflect localized forage assemblages rather than a preference for specific foods. Bearden and McKenzie (1969) also noted that feeding of red porgy appeared to be dependent on species availability rather than preference or selection. Theoretically, a large number of a food taxon found in a single fish may indicate that the animals were available in large aggregations. Usually a digestive tract contained only one to several individuals of a taxon. Only bivalves and small shrimps occurred in large numbers, the latter on one occasion more than one thousand in number.

Stomach contents of the red porgy indicate that the species is an opportunistic browser and feeds on practically any consumable sized animal available. This type of feeding has definite selective advantages since porgy are not dependent on only one or two specific food organisms. While competition for food among the offshore demersal fish (lutjanids, serranids, pomadasyids, balistids, and branchiostegids) is probably great, the trophic level at which *Pagrus* feeds is extensive with respect to diversity and biomass. Certain morphological characteristics aid the red porgy in feeding. They are fast enough to feed on such motile foods as small fish, portunid crabs, squids, and shrimp.

Observations made both in large aquaria and experimental fishing reveal *P. pagrus* to be a very aggressive feeder (personal observation). They generally seize the food (or bait) immediately when it is presented to them. Also, *P. pagrus* possesses strong molariform teeth which enable it to crush less motile, armored forms such as echinoderms, pagurid crabs, and gastropods. Hobson (1974), studying feeding of coral reef fishes in the Pacific, noted that the sparid, *Monotaxis grandoculis*, possesses strong dentition which enables it to feed competitively with diodontids, fishes with very strong jaws and pronounced dentition. Thus, the red porgy seems well adapted to feed on motile forms and also on relatively non-motile organisms which must depend on armor as a protection against predation.

The characteristics discussed above, and others, contribute to the red porgy's successful inhabitance of the outer Continental Shelf. The inshore distribution off the Carolinas is not completely understood. Very seldom is *P. pagrus* captured in water less than 20 m deep (personal observation). Generally, the species is replaced in shallower water by a community dominated by black sea bass, *Centropristis striata*, and white grunt, *Haemulon plumieri*. I believe the inshore exclusion is competitive rather than caused by an environmentally induced phenomenon such as temperature or substrate. By confining *Pagrus pagrus* in holding tanks, I have found that the species can tolerate rather drastic changes in temperature and, over relatively short periods of time. These conditions commonly occur in a temperate, aquatic environment similar to Carolina estuaries, and the inshore Continental Shelf area. Substrate does not seem to be the major limiting factor since irregular bottom inshore (< 13 fms), whether wreck or rock outcropping, very seldom produces red porgy. Since the black sea bass is an aggressive fish which occupies a specific "reef" area and has a diet similar to the red porgy, perhaps the sea bass and other closely related species successfully exclude *Pagrus pagrus* in the shallow, coastal Carolina waters.

Conclusions

(1) Sixty-nine specific food items were found in the digestive tracts of red porgy. These included 16 species of fish and 53 taxa of invertebrates.

(2) Invertebrates, consisting mainly of crustaceans, echinoderms, and mollusks were the dominant foods of adult fish occurring in 89% of the stomachs containing food. Pelecypod mollusks, sea urchins, majid, portunid, and calappid crabs occurred most frequently and contributed 29% of the total food volume. Crabs were the most diverse group of food organisms found in stomachs. Twenty-two species, representing seven families, were identified.

(3) Fish were of secondary importance in the diet of adult fish occurring in 24% of the red porgy and contributing 15% of the food volume. Fish identified were typically solitary, non-schooling, demersal species.

(4) Variables of season, geographic area, and depth of collection, had no apparent effect on frequency occurrences of food items in the diet. While larger juvenile red porgy (130–162 mm) and adults feed on similar foods, smaller juveniles (46–65 mm) consumed mainly amphipods, copepods, stomatopods, isopods, and annelids.

(5) The red porgy is an opportunistic browser which feeds predominately on benthic foods. Approximately 74% of the foods were classified as strictly benthic organisms and 90% of the volume was animals which are considered to be closely associated with the substrate. The red porgy is well adapted to compete with other fishes for motile prey, yet *Pagrus* possesses strong dentition which enables it to crush less motile, armored organisms such as pagurid crabs, echinoderms, and gastropods.

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